



**University of
Zurich**^{UZH}

**Zurich Open Repository and
Archive**

University of Zurich
University Library
Strickhofstrasse 39
CH-8057 Zurich
www.zora.uzh.ch

Year: 2018

Which egocentric direction suffers from visual attention during aided wayfinding?

Brügger, Annina ; Richter, Kai-Florian ; Fabrikant, Sara I

Abstract: Navigation systems are popular, as they support navigators in their everyday wayfinding activities. However, what happens to spatial knowledge acquisition and retention with increasing reliance on navigation system support? We conducted an outdoor wayfinding study with pedestrians, supported by the eye tracking data collection method, to investigate the role of navigation assistance on spatial knowledge acquisition. We specifically studied visual interactions with the environment between aided and unaided wayfinders. We observe that navigation system use significantly reduces forward and backwards glances during navigation, while glances to the right and left of the navigator along the route do not differ when comparing aided and unaided wayfinders. Our empirical findings shed new light on how the reliance of navigation assistance during way finding may affect navigators' engagement with the traversed environment, and how this in turn may affect spatial knowledge acquisition during wayfinding.

DOI: <https://doi.org/10.3929/ethz-b-000222472>

Posted at the Zurich Open Repository and Archive, University of Zurich

ZORA URL: <https://doi.org/10.5167/uzh-150382>

Conference or Workshop Item

Published Version

Originally published at:

Brügger, Annina; Richter, Kai-Florian; Fabrikant, Sara I (2018). Which egocentric direction suffers from visual attention during aided wayfinding? In: 3rd International Workshop on Eye Tracking for Spatial Research, Zürich, 14 January 2018. ETH Zurich, 22-27.

DOI: <https://doi.org/10.3929/ethz-b-000222472>



Conference Paper

Which egocentric direction suffers from visual attention during aided wayfinding?

Author(s):

Brügger, Annina; Richter, Kai-Florian; Fabrikant, Sara Irina

Publication Date:

2018-01-14

Permanent Link:

<https://doi.org/10.3929/ethz-b-000222472> →

Rights / License:

[Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International](#) →

This page was generated automatically upon download from the [ETH Zurich Research Collection](#). For more information please consult the [Terms of use](#).

Which egocentric direction suffers from visual attention during aided wayfinding?

Annina Brügger*, Kai-Florian Richter** and Sara Irina Fabrikant*

* Department of Geography, University of Zurich, Winterthurerstr.190, 8057 Zurich, Switzerland, annina.bruegger@geo.uzh.ch, sara.fabrikant@geo.uzh.ch

** Department of Computing Science, Umeå University, 90 187 Umeå, Sweden, kai-florian.richter@umu.se

Abstract. Navigation systems are popular, as they support navigators in their everyday wayfinding activities. However, what happens to spatial knowledge acquisition and retention with increasing reliance on navigation system support? We conducted an outdoor wayfinding study with pedestrians, supported by the eye tracking data collection method, to investigate the role of navigation assistance on spatial knowledge acquisition. We specifically studied visual interactions with the environment between aided and unaided wayfinders. We observe that navigation system use significantly reduces forward and backwards glances during navigation, while glances to the right and left of the navigator along the route do not differ when comparing aided and unaided wayfinders. Our empirical findings shed new light on how the reliance of navigation assistance during wayfinding may affect navigators' engagement with the traversed environment, and how this in turn may affect spatial knowledge acquisition during wayfinding.

1. Introduction

Aided wayfinding (Wiener et al., 2009), for example by means of a navigation system, has negative effects on spatial awareness, orientation, and spatial memory (e.g., Adler, 2001; Gardony et al., 2013; Parush et al., 2007). One reason may be because navigators divide their attention between the environment and the navigation assistance during aided wayfinding. The eye tracking data collection method has become a popular tool to analyze navigation behavior (Kiefer et al., 2017), specifically because the attention allocation between navigation assistance and the traversed environment can be systematically studied. Most navigation studies supported by eye

tracking analyses to date have focused on environmental features that attract a navigator's attention (e.g., Wenczel et al., 2017), the matching of map content with environmental features (e.g., Kiefer et al., 2013), or the comparison of different wayfinding support tools (e.g., Ohm et al., 2017). However, we still have a poor understanding of wayfinders' viewing behaviors during assisted wayfinding, specifically related to body movement direction. For example, Lander et al. (2017) compared head movements with eye tracking data in horizontal and vertical direction during aided (verbal audio instruction) wayfinding. They found that participants moved their heads more than their eyes. A study focusing on assisted car drivers' fixations in movement direction (i.e., forward, right, left, rear-mirror, and over the shoulder) shows a significant difference in fixations to the side, when using either a navigation system or a printed map (Haupt et al., 2015). These authors argue that the printed map forced the drivers to find relevant orientation information in the environment, and therefore, their proportion of fixations to the side was higher than when using a navigation system. These studies motivated us to specifically employ the eye tracking data collection method for our empirical wayfinding study. We thus present results of an eye tracking study to better understand the first-person viewing behavior of pedestrians during unaided and aided wayfinding.

2. Method

We analyzed eye tracking data of 15 participants (4 men, 11 women) in an urban outdoor environment. The participants have an average age of 24.9 years and are unfamiliar with the study area. The experimental task consisted of two parts: aided (incidental learning phase) and unaided (recall phase) route following. In the aided route following part of the experiment, participants were asked to use a navigation system and to follow a pre-defined route (800 m, 14 intersections, 3 right and 3 left turns). A SAMSUNG Galaxy Tab S10.2 tablet with an application using an allocentric interactive map (Google Maps API) was used. There were no text or voice instructions. All participants performed a short training session on how they can use this digital navigation aid. During the unaided part of the route following task, participants had to find their way back without navigation assistance. Each participant wore a pair of SMI eye-tracking glasses, attached to a recording laptop worn in a backpack during both experimental tasks. For the post-task eye tracking data analysis, a reference image (Figure 1) was used to annotate each fixation of the participants to an area of interest (AOI). The reference image holds four AOIs, delineated according to the navigator's egocentric viewing directions (F: forward, B: backwards, R: right, L: left), in addition to fixations on the navigation assistance (NavSys:

navigation system). The navigation assistance AOI was not further analyzed during the second, unaided part of the experiment, as participants did not have access to the navigation system then.



Figure 1. Example reference image (left) to annotate navigators' eye fixations according to the four egocentric viewing directions (F: forward, B: backwards, R: right, L: left) including the navigation aid (NavSys: navigation system). Each section in the reference image represents one area of interest (AOI). The egocentric viewing directions along the route are projected on a photo of the experimental scene (right).

3. Results

To assess aided and unaided wayfinding viewing behaviors, we scored and compared fixation numbers between the five (aided) AOIs and the four (unaided) AOIs as described in Figure 1. We scored the total number of fixations in an AOI as a proportion to the total number of fixations (separately for aided and unaided wayfinding types). Figure 2 presents an overview of the percentages of annotations in each egocentric direction for both wayfinding types as well as the navigation system during aided wayfinding. Participants put between 18% and 48% of the fixations on the navigation system. The proportion of fixations in participants' forward direction is highest during both, aided and unaided wayfinding, but the percentage of fixations in forward direction between aided and unaided wayfinding task varies. On average, participants fixated environmental features in the forward movement direction significantly more during unaided wayfinding ($M_{\text{percent}} = 90.59$, $SD_{\text{percent}} = 4.37$), compared to aided wayfinding ($M_{\text{percent}} = 56.68$, $SD_{\text{percent}} = 11.64$). This difference is statistically significant ($t(14) = -13.965$, $p < .01$, $r = 0.966$). The proportion of fixations in backwards direction also significantly differs between aided ($M_{\text{percent}} = 0.30$, $SD_{\text{percent}} = 0.36$) and unaided ($M_{\text{percent}} = 1.09$, $SD_{\text{percent}} = 1.309$) wayfinding ($t(14) = -2.6735$, $p < .05$, $r = 0.581$). No significant difference in fixations comparing egocentric right

($t(14) = -0.91814$, $p > .05$) or left ($t(14) = -0.90064$, $p > .05$) direction was found between aided and unaided wayfinders.

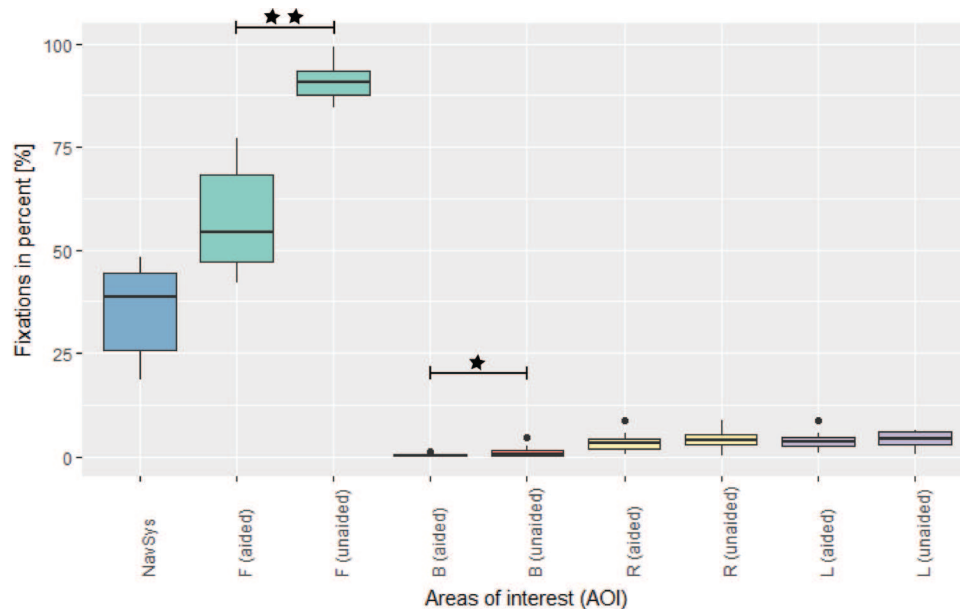


Figure 2. Fixation percentages in four egocentric directions (F: forward, B: backwards, R: right, L: left) and the navigation system (NavSys: navigation system) for aided and unaided wayfinding tasks. Forward (**; $p < .01$) and backward (*; $p < .05$) fixation percentages differ significantly between aided and unaided wayfinding tasks.

4. Discussion and Conclusion

We systematically assessed pedestrian wayfinders' viewing interactions with the traversed environment during aided and unaided wayfinding by means of eye fixation analysis. Our empirical results reveal that pedestrians look at the device in expense of fixations in direction of movement (forward). This finding is consistent with previous work carried out with car drivers (Haupt et al., 2015) and may help us to better understand divided attention with navigation assistance (e.g. Gardony et al., 2013). Interestingly, we did not find more fixations to the right or to the left side of the navigator when omitting the navigation system. This result is contrary to that of Haupt et al. (2015), who found increased body rotations when car drivers use navigation aids. They suggested that a change in body movement indicates a search for orientation information. As we find an increase in backwards fixations, we contend that pedestrians do look backwards for orientation anchors during unaided wayfinding when recalling a route; however, they do not turn their head backwards as much during aided wayfinding

(incidental learning phase). The significant difference in backwards fixations likely occurs because participants travel the same route again in opposite direction, and may want to recreate the same view of a spatial scene they had when traveling the route in the first place. Therefore, the experimental design used for this study influenced the result of backwards fixations which also highlights the importance of fixations in forward direction during aided wayfinding. One implication for aided wayfinders could be that they have to turn around (fixations in the reverse direction) to make it easier to recall the path.

Overall, our results indicate that aided wayfinding influences pedestrians' navigation behavior in only two out of the four possible egocentric viewing directions. These findings uncovered by means of eye tracking data analysis may help us to better understand wayfinding behavior differences between aided (knowledge acquisition phase) and unaided (recall phase) navigation, and in turn to design future navigation systems that take into account navigators gaze behavior during spatial recall tasks. With such systems, aided wayfinders will then adjust their gaze behavior to a potential recall task and in case of system failure, have acquired enough spatial knowledge to efficiently orient and navigate unaided from a system, but aided from memory.

References

- J L Adler. Investigating the learning effects of route guidance and traffic advisories on route choice behavior. *Transportation Research Part C: Emerging Technologies*, 9(1):1–14, 2001
- A L Gardony, T T Brunyé, C R Mahoney, and H A Taylor. How navigational aids impair spatial memory: Evidence for divided attention. *Spatial Cognition and Computation*, 13(4):319–350, 2013
- J Haupt, N van Nes, and R Risser. Look where you have to go! a field study comparing looking behaviour at urban intersections using a navigation system or a printed route instruction. *Transportation Research Part F: Traffic Psychology and Behaviour*, 34:122–140, 2015
- P Kiefer, I Giannopoulos, and M Raubal. Where Am I? Investigating Map Matching During Self-Localization With Mobile Eye Tracking in an Urban Environment. *Transactions in GIS*, 18(5):660–686, 2013
- P Kiefer, I Giannopoulos, M Raubal, and A Duchowski. Eye tracking for spatial research: Cognition, computation, challenges. *Spatial Cognition & Computation*, 17(1-2):1–19, 2017
- C Lander, F Wiehr, N Herbig, A Krüger, and M Löchtefeld. Inferring landmarks for pedestrian navigation from mobile eye-tracking data and google street view. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, CHI EA '17, pages 2721–2729, New York, NY, USA, 2017. ACM
- C Ohm, M Müller, and B Ludwig. Evaluating indoor pedestrian navigation interfaces using mobile eye tracking. *Spatial Cognition & Computation*, 17(1-2):89–120, 2017
- A Parush, S Ahuvia, and I Erev. Degradation in spatial knowledge acquisition when using automatic navigation systems. In S Winter, M Duckham, L Kulik, and B Kuipers, editors,

- Spatial Information Theory: COSIT 2007, pages 238–254. Springer Berlin Heidelberg, 2007
- F Wenzel, L Hepperle, and R von Stülpnagel. Gaze behavior during incidental and intentional navigation in an outdoor environment. *Spatial Cognition & Computation*, 17(1-2):121–142, 2017
- J Wiener, J S Büchner, and C Hölscher. Taxonomy of human wayfinding tasks: A knowledge-based approach. *Spatial Cognition & Computation*, 9(2):152–165, 2009